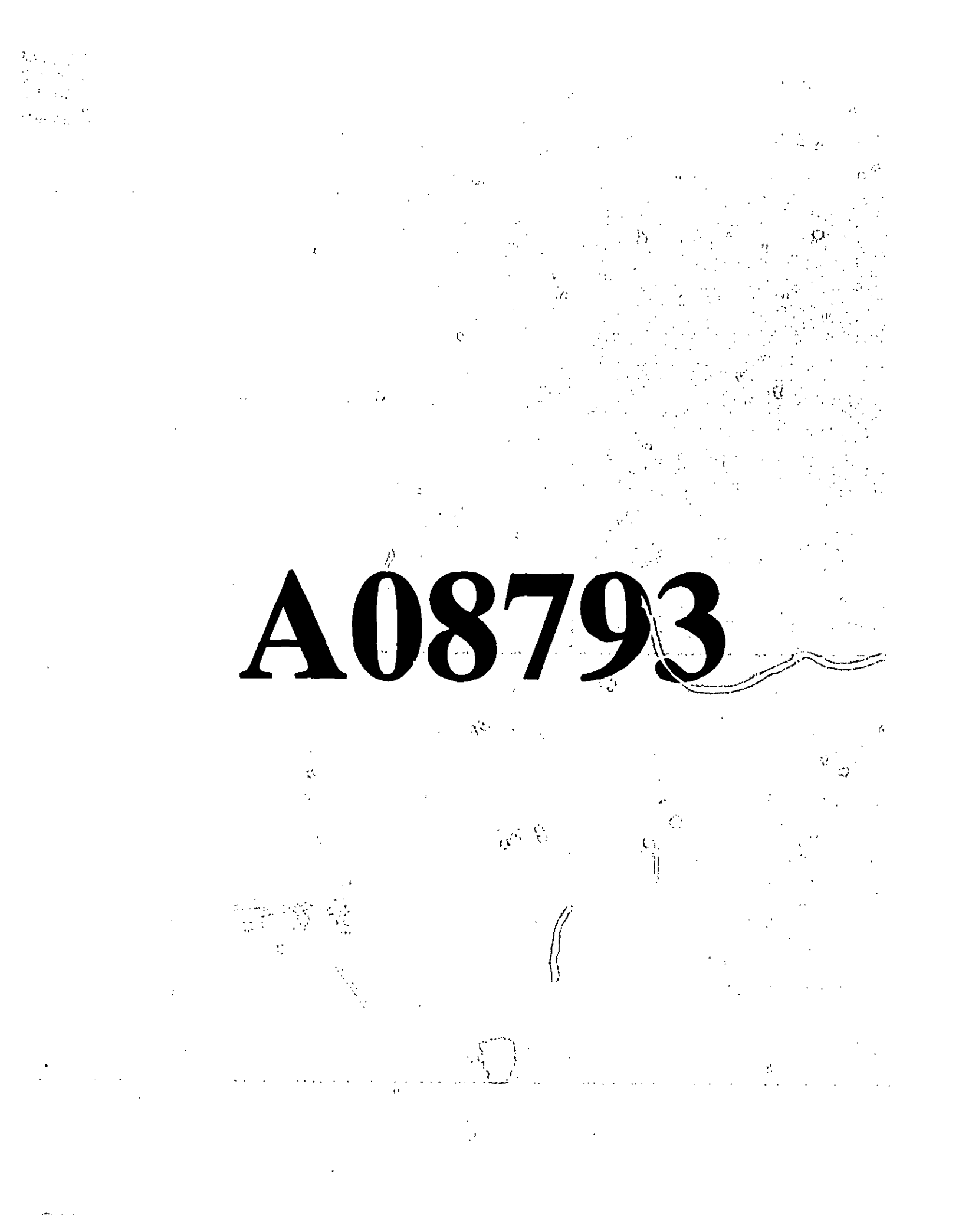
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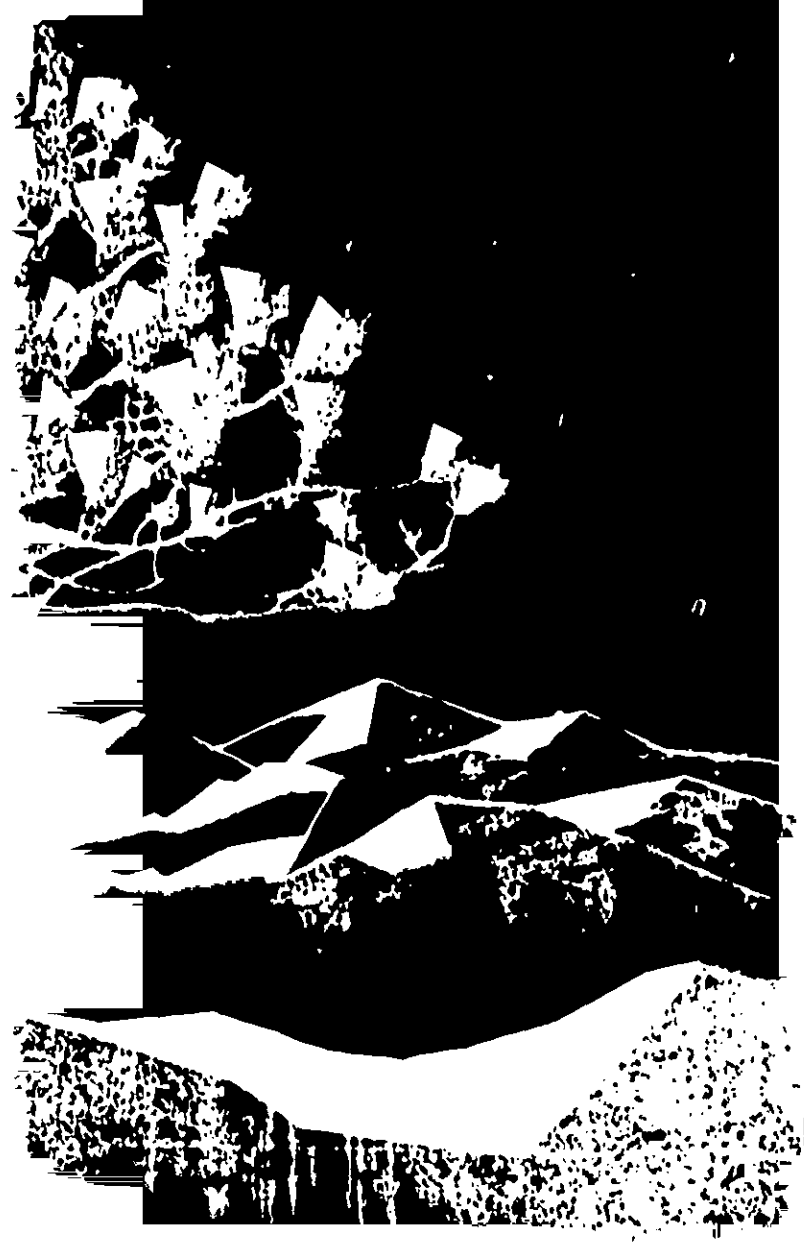

A Literature Review on Waterfowl Production and Habitat Manipulation

by

David R. Anderson

Graduate Research Assistant

Colorado Cooperative Wildlife Research Unit
Colorado State University
Fort Collins, Colorado

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Cooperating Agencies

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Fred A. Glover, Leader

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Foreword

This is the first report of a research program that is intended to provide the Division of Wildlife Refuges answers to specific management problems. Unlike other kinds of research, which are frequently aimed at securing answers to fundamental questions that are of interest to wildlife managers in general, this new approach emphasizes specific management problems. The answers provided by *"problem oriented" investigations* will lead to the development of new or modified management techniques that are applied as a direct result of the studies. This is, then, research of a most important *sort — research* that *helps on-the-ground* refuge managers do a better job.

The need for the "early water study" became apparent when observations revealed erratic waterfowl nesting patterns where the presence of water in early spring appeared to be more important than plant cover characteristics.

The research program of which this report is the beginning is the first of several such studies being undertaken or planned by the Division of *Wildlife Refuges*, working with *Cooperative* Wildlife Research Units to solve management problems now faced on national wildlife refuges. In addition, students of the profession will have an opportunity *to contribute to their own development.* This, I believe, is wildlife work of the highest order.

The study incorporates some of the newest concepts of statistical analysis, including the use of electronic computer equipment. This in itself will be a major step forward in the field of wildlife research - one that will have application in other such research endeavors.

The problems that face refuge managers in the task of managing wildlife as intensively as possible are manifold. We know that these problems must be solved if we are to derive from the nation's wildlife refuges their fullest potential. Research directed to the solution of these problems is the key to success in the not-so-simple job of wildlife refuge management, and we, as managers of the National Wildlife Refuge System, are pleased to have a part in this effort.

Marcus C. Nelson

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Introduction

Waterfowl suffer the effects of human population increase in two important ways: (1) reduction of essential wetland habitat and (2) increase in the number of waterfowl hunters (Hawkins et al., 1958). Hawkins et al. (1958) estimated that Americans spent 115 million dollars in 1955 just to hunt waterfowl but more important the esthetic value is probably larger. To date, waterfowl managers have worked almost exclusively with tangible values involving the number of hunters, the number of birds harvested, and the dollars spent. It is now time to assess the esthetic, cultural, and traditional aspects of wildfowl values so they, too, can be used to justify the need for saving wetlands and waterfowl (Hawkins et al., 1958). One answer to the problem of decreasing wetland habitat seems to lie in research designed to increase waterfowl production on existing areas. Leopold (1933) was one of the first to recognize the importance of interspersion and juxtaposition. Field investigations indicate waterfowl nesting is almost universally associated with "edges" (Griffith, 1948).

Waterfowl management requires knowledge of waterfowl and their habitat, so that within limits of existing economic and social conditions we can apply this knowledge to help the public receive maximum benefits from this resource. This means maintaining waterfowl breeding grounds at high levels and providing better, high quality habitat for breeding birds. This places on management the obligation of assembling, analyzing and applying a great volume of factual information, some already on hand but much more of which must be secured (Hawkins et al., 1958).

Management procedures must be based on sound biological research. As Kalmbach (1939) stated:

"Simple processes of reasoning are not always the soundest. Contentions that seem readily apparent may in fact be deficient through neglect of important factors, lack of proper perspective, absence of sufficient evidence to obliterate temporary or local distortions, or through other circumstances that might lead to faulty deductions. Opinions regarding wildlife relationships are frequently based on imperfect evidence, and, probably more than in any other field of human thought, there also crops up that chronic mental quirk of being most easily convinced of that which is most satisfying to believe."

This paper is an intensive review of published literature that summarizes the results of research designed to increase waterfowl production on existing areas.

Methods of Increasing the Water- Land Ratio

Artificial Potholes

Findings of numerous investigations have shown the inefficiency of habitat in which the cover type is dense and continuous (Hammond and Mann, 1956; Jahn and Hunt, 1964; Lacy, 1959; Scott and Dever, 1940). The game manager, cognizant of this evidence, has attempted to remove restrictions of habitat by opening them (Scott and Dever, 1940).

Money available through the Prairie Farm Rehabilitation Act and Ducks Unlimited is being used to establish permanent impoundments in Canada (Keith, 1961). In the United States, Federal agencies and many states, as well as private organizations, are restoring and developing wetlands suitable as breeding, feeding, and resting grounds for waterfowl (Hopper, 1962).

Numerous studies have been made in an attempt to evaluate the effect of artificial potholes on waterfowl production. Jahn and Hunt (1964) suggested that when planning small, shallow impoundments for duck production, the development of clusters of water areas, rather than isolated single units, should be encouraged. The greatest use of artificial potholes by waterfowl was found to partially depend on the level of the water during the breeding season (Shearer, 1960). Most use of ponds by waterfowl was made on areas with the water level close to the soil surface (Shearer, 1960).

Jahn and Hunt (1964) suggested the excavation of filled lake and marsh basins having the water table close to the soil surface. Large sized areas (5 to 10 acres) with irregular shapes and having desired cover patterns are generally preferred to oval shapes and with little or no emergent cover (Bradley, 1960). Shearer (1960) indicated that the use of artificial potholes was greater where the surrounding cover was good.

Provost (1948) studied dynamited clearings in sedge marshes and found the bare shoulders of each dynamited area to be the main attraction, as they constituted ideal resting sites, especially to blue-winged teal (Anas discors). Excavations should be as close as possible to good upland nesting sites to be of maximum benefit to puddle ducks (Provost, 1948).

Smith (1953) evaluated waterfowl use by size of the pothole and vegetative type and found that, on the average, the larger the pond the greater the usage (significant at the one per cent level). "The relationship between brood production and vegetative type was not as pronounced and striking as the relationship between brood production and pothole size" (Smith, 1953).

An excavation in the shape of a cross with a 5 to 20-acre pool in the center will provide maximum "edge" and interspersion at minimum cost (Provost, 1948). Bensen and Foley (1956) concluded that duck production decreases after the third year of impoundment under acid soil conditions in New York.

Provost (1948) concluded that "... in final appraisal, blasting, while it creates better interspersion, has little effect on nesting substrate value of the surrounding cover. This difficulty can be minimized by careful selection of the area to be blasted."

The development of artificial potholes probably should be used as a management tool in conjunction with other management practices such as water level manipulation and vegetation control.

Natural Potholes

The majority of the continental waterfowl is produced on natural potholes. McNamara (1957) reported that states faced with the problems of decreasing wetland areas recognize the potential of small waterfowl areas as a tool for habitat restoration and maintenance. McNamara (1957) believed:

"The full potential can be realized by careful and intensive planning. An integral part of this planning should be the preservation of potholes and small natural watershed areas of high quality that are present at this time. Any planning should be made in accordance with flyway objectives, based on the realization that waterfowl are not distributed equally between states but that distribution is influenced to a large extent by the presence of adequate and specialized habitat."

Nesting Islands

During the middle 1950's much attention was focused on nesting islands in an attempt to increase waterfowl production. Hammond and Mann (1956) suggested three values that nesting islands possess: (1) relative freedom from disturbance by predators (2) a greater capacity for territorial occupancy because of the high ratio of water to land, and (3) close proximity of water, food, loafing sites and nesting cover.

Griffith (1948) and many other authors believed that dabbling ducks nest primarily within 450 feet of water and the greatest number of nests were found not more than 150 feet from the water. This fact emphasizes the importance of "edge effect" and nesting islands to waterfowl production.

A study by Uhler (1956) on nesting islands at the Patuxent Wildlife Refuge in Maryland revealed disadvantages of islands excavated using a bulldozer or dragline. He explained that the greatest problem to the successful use of islands for waterfowl was the destruction by wave action and muskrats.

Hammond and Mann (1956) hypothesized that geese and many species of ducks quickly learn to take advantage of the sites where predation is avoided. These writers further concluded that geese and gadwalls (Anas strepera) have the greatest inclination to attain unusual nest densities. Mallard (Anas platyrhynchos) and pintail (Anas acuta) often reach greater nesting densities than would normally be expected.

Weeds often invade shortly after the completion of a nesting island; however, Hammond and Mann (1956) concluded that vegetation is of minor importance as a nesting factor unless it is too tall and rank. Griffith (1957) summarized:

"Nesting islands well located in relation to exposure, essential factors of breeding ground habitat, and possible invasion by predators and man can add greatly to local waterfowl production. The investment required for large islands is seldom justified, however, small islands built just within the edge of a marsh usually have a high cost benefit ratio."

Level Ditches

Griffith (1948) explained:

"The extent of nesting is proportionate to the character and quality of marsh vegetation occurring along the shoreline and in the shallow water. Where such growth is lacking, little or no nesting occurs, even though food is available. Thus a meadow, which by all recognized standards can be classed as excellent nesting cover, is not occupied or is used only by an occasional bird because there is an absence of shoreline vegetation to provide concealment for the broods, as well as the adults."

Many examples of the importance of "edge" can be found in the literature (Hammond and Mann, 1956; Jahn and Hunt, 1964; Lacy, 1959; Scott and Dever, 1940). Excavation of level ditches either by blasting or digging has provided waterfowl managers with a new management technique. Intensive studies of the value of level ditching have been made in Wisconsin by Mathiak (1953). Lacy (1959), studying the effects of level ditches at the Lower Souris Refuge in North Dakota, concluded level ditches have their greatest value as a supplement to nearby marshes by providing the isolated small water areas necessary during the br[illegible]ing season. Since little use was made of the ditch[illegible]oods, feeding or migrating ducks, the primary value of artificial ditches lies in the fulfillment of territorial requirements of breeding pairs in conjunction with the habitat provided by nearby marshes.

The largest single factor limiting increased waterfowl production on ditched areas seems to be predation; however, the number of duck nests found on the experimental ditch spoil banks makes it apparent that level ditching can be an important tool in waterfowl production (Mathiak, 1953).

Water Level Fluctuation

Naturally Fluctuating Water Levels

Rogers (1959) suggested that little is known about the close relationship between changes in water levels and waterfowl production and use. Glover (1956) reported that several studies have indicated alteration of water levels can bring about a profound change in vegetation. He further speculated that this procedure could be used as a management tool to increase, in part, the extent of "edge."

Fluctuation of water levels can bring about significant changes in aquatic vegetation (Hayden, 1943; Provost, 1947; Moyle and Hotchkiss, 1945; and Bellrose, 1941). Griffith (1957) felt that "Water level management is a highly effective method of managing habitat for the protection, production, and utilization of waterfowl." Both fauna and flora can be radically changed by regulating water levels (Bourn and Cottam, 1939).

Waterfowl brood movements appeared to be stimulated by high or rising water levels (Evans et al., 1952). Wolf (1955) concluded that brood survival was probably not affected by falling, stable, or fluctuating water levels.

Hochbaum (1944) suggested that adult birds which have bred in a given locality will tend to return there for subsequent nestings, but young

mallards do not necessarily breed in the precise area where hatched if there are more attractive grounds nearby. Mayhew (1955), while studying mallard production in the Sacramento Valley of California, believed that in years of low spring rainfall the young birds passed over such areas due to lack of water on which to establish a territory. He suggested that the reduction in numbers of breeding pairs during the study (1949-50) was probably due to a reduction in attractiveness of the area, because of dry conditions during those years.

Rogers (1959), in a study near Delta, Manitoba, determined that production of the lesser scaup (Aythya affinis) declined due to: (1) greater vulnerability of the nests to predators and (2) failure of birds to renest in dried-out cover, both as a result of low precipitation and low water levels. Hunt and Naylor (1955) concluded:

"The amount of water in Honey Lake has a definite bearing on the numbers of waterfowl using the valley throughout the year. The lake in wet years provided an adequate nesting place for spring migrants and attracts breeding pairs that remain to nest in the area."

Anderson (1956) found that low water levels concentrated ducks and increased predation in California.

Earl (1950) investigated mallard production in the Sacramento Valley of California and found that 400 pairs of birds increased to 2,000 birds in the fall with 5.01 inches of rainfall during the nesting season. Mayhew (1955) studied the same area a few years later and found that 260 pairs decreased to only 210 birds with 0.38 inches of rainfall. The amount of rainfall during the nesting season probably not only affected the nest success and brood survival but also determined, in part, the amount of suitable nesting habitat.

"Breeding pair populations on the Redvers area in Saskatchewan seemed to follow changes in water levels more closely than they did the number of water areas" (Stoudt, 1964a). Stoudt (1964b), while studying the habitat requirements of the canvasback (Aythya valisineria), found no flooded nests on the study area but some loss was caused by predators. He believed this predation was partially caused by the nests being stranded on dry land.

While water level fluctuation can be a valuable management tool, it also can be detrimental to waterfowl production if the fluctuation is irregular or extreme, especially during the nesting period. Anderson (1941), Bellrose and Brown (1941), Low and Bellrose (1944) and Wiebe (1946) have cited the unfavorable effects of water levels on waterfowl production and food plants. No single factor is more important in preventing the development of waterfowl food plants and nesting cover than extreme or irregular water fluctuations (Martin and Uhler, 1939).

Anderson 1941), while studying waterfowl and their habitat conditions along the Illinois River Valley, concluded that "Stabilization of water levels is the most important present step required for restoring satisfactory marsh conditions." Williams and Marshall (1938) noted duck nests destroyed by flooding on the Bear River Refuge in Utah. Wolf (1955) found that mallard and redhead (Aythya americana) attempted to save their clutches by building nests higher as the water level rose. He concluded that a rate of rise of 0.166 feet per day for five days damaged 53 percent of the flooded mallard nests. Johnsgard (1956) reported "Flooding of the larger potholes has greatly reduced total waterfowl production and has forced the breeding waterfowl into the remaining smaller potholes."

Managed Drawdowns

Recent investigations in Ohio and Michigan have attempted to determine changes in vegetation, waterfowl production, use and harvest as a result of managed water level fluctuations. Bednarik and Thompson (1965), after studying the effect of drawdowns on Magee Marsh in Ohio, observed the number of territorial pairs to have risen steadily from 54 in 1953 to 251 in 1964. Drawdowns in Michigan have resulted in substantial changes in vegetation but the value to waterfowl production during the study was minimal (Kadlec, 1960). He concluded that drawdowns should be employed on an individual basis and that the drawdown technique is not a panacea for all marsh management problems. A wide variety of other techniques, such as burning, herbicides and level ditching have been shown to be effective in certain instances. In fact, some of these are admirably suited for use in conjunction with a drawdown.

Grazing Practices

Under undisturbed conditions dense stands of vegetation decrease the suitability of the cover for breeding ducks (Sowls, 1955; Bue et al., 1952; Keith, 1961). Griffith (1957) concluded that grazing with proper regulation is an effective and economical means of maintaining some breeding habitats

in balance.

Griffith (1957) stated that:

"The accumulation of evidence on the relationship between edge and full utilization of nesting cover has led to using livestock as a means of cover management. Limited grazing in nesting territories and particularly along shorelines can be directed so as to obtain the desired edge effect and not damage the brood cover nor seriously impair food supplies. Grazing must be applied very cautiously, however, to avoid serious complications. Overgrazed lands are practically worthless to nesting waterfowl. On potholes and sloughs, as on protected shorelines where comparatively stable water levels permit belts of emergent growth to develop, the potentialities for waterfowl utilization can be impaired greatly or wiped out completely by uncontrolled grazing."

Several studies indicate that light grazing actually increases waterfowl production. Higher nest densities on areas with light grazing in contrast to no grazing have been found (Glover, 1956). Light grazing (14.9 cattle days per acre per year) had no adverse effects on waterfowl production, Bue et al., 1952. They further concluded that light grazing (27 acres per cow per year) and fencing portions of the stock pond shorelines would increase duck production. Bennett (1937) concluded from studies in Iowa that light grazing actually benefitted duck production. Allen (1939) concluded that any pond improved for wildlife in the southern high plains must be fenced or at least partially fenced.

Glover (1956) suggested that moderate grazing may be permitted after July 1. Bennett (1937) concluded that grazing intensities of one cow per six acres in normal years appeared to increase waterfowl production in Iowa. Nest loss due to trampling by cattle was found to be an insignificant factor in nest failure in Idaho (Steel et al., 1956).

Unpublished studies conducted on several north-central national wildlife refuges suggest predation losses are often severe on grazed areas as compared to nearby ungrazed areas.

Bue et al. (1952) found that grass shoreline types supported two or three times as many pairs of breeding birds as mud type shorelines. Also, ponds with grass-type shorelines were utilized by broods three or four times as much as those with mud type shorelines. Pond size appeared to have more influence on brood usage in Montana than vegetative class; however, ponds with vegetation were utilized more than those without (Berg, 1956). Salyer (1962) thought that nesting densities and nesting success were probably more attributable to water distribution than grazing intensity in Canada.

Control of Vegetation

Controlled Burning

Extensive stands of unbroken potential habitat attract very few nesting birds (Griffith, 1948). Controlled burning may be an effective management tool to increase waterfowl production on these areas. Published literature relating burning of marsh areas to provide suitable nesting cover is limited. Most literature deals with improvement of habitat for feeding grounds, particularly for wintering concentrations of geese.

Glover (1956), while studying the blue-winged teal in Iowa, reported decreased nesting after a fire. Production of the American coot (Fulica americana) may be decreased and waterfowl production increased by controlling cattail (Typha sp.) and establishing desirable emergent species by planting (Ryder, 1961). Griffith (1948) stated that controlled burning is important in connection with 2,4-D applications in the control of cattail. Burning removes the old growth and brings about temporary changes in plant succession which greatly influence food production.

Jahn and Hunt (1964) suggested the use of fire to maintain herbaceous and grassy nesting cover adjacent to shallow water areas having suitable aquatic escape cover and plant and animal foods. Fire is probably the best single tool available for the control of undesirable vegetation. It is inexpensive to use and highly effective; but it must be carefully controlled or serious damage may result (Uhler, 1944).

Chemical Control

Little work has been done in an effort to relate the effects of chemically controlled vegetation to waterfowl production. Bauman (1947) suggested spraying broad-leafed emergent vegetation with ammonium sulfamate. Arrowhead (Sagittaria latifolia), American lotus (Nelumbo lutea), cattail (Typha latifolia), water primrose (Jussiaea diffusa), duckweed (Lemna minor), and black willow (Salix nigra) were successfully killed using ammonium sulfamate and "Vatsol O S," but the value of the controlled vegetation to waterfowl production was not determined. This chemical appeared

to be nontoxic to livestock.

Many other chemicals have been used, such as "Dowpon," 2,4,5-T and 2,4-D to control vegetation. The success of chemically controlled vegetation usually depends on the time of spraying, method of application and the amount of chemical used. These factors are usually different for different species of vegetation.

Martin et al. (1957) reviewed many chemical methods of vegetation control designed to improve duck marshes but made no study to evaluate the effects of the control on waterfowl production. Chemicals are often expensive and usually ineffective if not properly applied (Uhler, 1944).

Artificial Nesting Structures

Many investigators have suggested the use of artificial nesting structures in habitats lacking natural nesting sites as a means of increasing production. Artificial nesting structures have been most successful with Canada geese (Branta canadensis) and wood duck (Aix sponsa) (Yocom, 1952; Klein, 1955; McLaughlin and Grice, 1952). Woven reed structures have been tried for other species at the Delta Waterfowl Research Station in Manitoba. Box, barrel and basket-type nests for ground nesting species have been tried along the coast of Finland and in Holland (Grenquist, 1958).

McLaughlin and Grice (1952), studying the effectiveness of a large-scale nesting box program in Massachusetts, found that 44.6 per cent of 3203 boxes were used by wood ducks. They found that 64 per cent of the nests were successful, somewhat higher than the average success rates of ground nesting waterfowl.

Raccoon (Procyon lotor) predation and nest abandonment appeared to be important factors reducing production in Massachusetts (McLaughlin and Grice, 1952). Klein (1955) concluded that there was a definite need for wood duck nesting boxes in New York; however, nest predation by raccoons is often an important factor. The amount of light reaching the nest and the type of nesting box most influenced a duck's choice of a box for nesting site (Klein, 1955). Webster and Uhler (1964) stated "It was formerly believed that old, weather-stained structures were more attractive to wood ducks, but most recent evidence shows that conspicuous, new structures are more readily used, probably because they are more easily seen."

McLaughlin and Grice (1952) presented evidence supporting the hypothesis that nest abandonment is density-dependent (Table 1). The effect of human intrusion on nest abandonment is not known.

Table 1. Relationship between the per cent usage and the per cent of nests abandoned McLaughlin and Grice (1952).

Percent Usage	Percent of Nests Abandoned
0 - 20	11.4
21 - 40	10.0
41 - 60	14.4
61 - 80	15.3
81 - 100	25.5

McLaughlin and Grice (1952) listed the following reasons that could explain the increased production due to the availability of nesting boxes: (1) influx of birds from nearby areas and (2) ducks ordinarily nesting farther north were "short-stopped." Maintenance and predation seem to be a continual problem with long-term nest box programs.

The success of wood duck nesting structures is often complicated by the fact that they are used by a variety of other wildlife species. Webster and Uhler (1964) stressed that nest structures do more harm than good where predators destroy eggs laid by ducks attracted to these structures.

Artificial Barriers to Reduce Territory Size

Much confusion exists as to the possibility of intolerance and the defense of territories as a limiting factor to waterfowl production. Present literature indicates that visual isolation will decrease intolerance and possibly territory size, if territorial defense is a limiting factor (Sill, 1964).

Lacy (1950), studying the effects of level ditching at Lower Souris Refuge in North Dakota, found that frequent bends in ditches would increase the number of breeding pairs by providing visual isolation of one pair from another, thereby increasing the number of defended sites.

Stoudt (1964a) postulated that the carrying capacity of some of the waterfowl breeding grounds may depend on drake intolerance and water availability. Glover (1956) suggested experimenting with artificial objects along the shoreline to act as male waiting stations. This would be an effort to make areas more attractive to breeding ducks.

Sill (1964) believed that with waterfowl habitat decreasing, and an inevitable lowering of the potential for maintaining waterfowl populations, we should endeavor to modify habitat so that birds will nest in greater concentrations than now take place. After studying the effect of nylon barriers on waterfowl production in Utah, he concluded that more birds used the control areas than the experimental areas during the first year of study.

Territorialism in birds tends to limit the number of breeding pairs for each area (Low, 1947). He stated: "Nest densities, which in Utah marshes reach as high as 10 to the acre and three or four times as great on small areas of choice nesting cover, obscure clear-cut territorialism."

Summary

To be successful, management techniques must be inexpensive, flexible and highly effective (Griffith, 1948). In general, artificial potholes, level ditches and nesting islands are valuable methods for increasing production but are usually difficult to justify economically.

At the present time it appears there is little we can do about increasing production of waterfowl in the face of drastically fluctuating water levels. Little is known about the long-term effects concerning the relationship between plant succession and waterfowl production as a result of controlled water level fluctuations. Managed drawdowns are probably of most value on state and federal waterfowl areas where systems of dikes and levees are available for water control.

It is apparent from the literature that light grazing will generally increase waterfowl nesting on areas of dense vegetative growth; however, recent evidence indicates grazed areas may suffer significantly greater predation losses than nearby ungrazed areas. In arid regions where wetland areas are used by cattle during the nesting period it may be necessary to fence part of the pond and surrounding cover.

When nesting cover is extremely tall and dense it can often be improved by controlled burning. The area of chemically controlled vegetation in relation to waterfowl production is virtually unexplored. Artificial nesting structures are especially important to Canada geese and wood ducks. Artificial nesting structures as well as artificial potholes and level ditches are usually plagued by severe predation.

The use of artificial barriers to reduce territory size has often been suggested but, until recently, has not been specifically studied. The results to date appear to point to still unanswered questions concerning territorialism, territory size and the density-dependence of nesting waterfowl.

A management tool that is inexpensive, flexible and highly effective has not been discovered. The answer to the problem of increasing waterfowl production on existing areas probably lies in continuing ecological research designed to provide answers to specific questions.

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